Performance and exhaust gas emission of gasoline engine fueled by gasoline, acetone, and wet methanol blends

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1. Introduction

Vehicle growth has a serious impact on a variety of things, including increased emissions and fuel consumption. Vehicle fuel consumption is affected by the acceleration process. Low octane values reduce vehicle acceleration. Fuels that contain low octane values make fuel consumption increase. The higher the octane value of the fuel, the better the engine performance [1].

Acetone and wet methanol are derivatives of alcohols that have high octane values. Ashraf and Chang mix acetone on fuel. The results obtained show an increase in engine performance. Torque and break power on the test machine has increased, while the CO content in emissions has decreased significantly [2][3]. Mixing acetone containing water in gasoline engines can reduce CO and NO_x emissions [4].

Mixing of octane number 88 fuel with 110 octane number methanol on 1000cc EFI 4 cylinder gasoline engine.The results show an increase in engine performance and emission reduction [5]. This oxygen level in methanol influences engine performance [6]. The addition of methanol makes it easy to start the engine when it's cold. The resulting CO and HC emissions have decreased. [7]. Methanol and fuel mixtures on gasoline engines with exhaust gas recirculated (EGR) systems can increase torque and brake power. BSFC has decreased due to the addition of the EGR system [8].

The use of acetone and wet methanol as a premium fuel mixture is expected to improve engine performance and reduce emissions. Engine performance includes the measurement of Brake Power and BSFC. Emissions include measuring CO and HC levels. This research was conducted to test whether the performance and emissions produced using the mixture are better or not.

2. Method

Performance and emission test equipment on gasoline engines are arranged according to figure 1. The fuels used are P (premium), A (acetone) and W (wet methanol). The mixed variable between acetone, wet methanol and premium is in percent (P100), (A10, P90), (A10, W5, P85), (A10, W10, P80), (A10, W15, P75), (A20, P80) , (A20, W5, P75), (A20, W10, P70), (A20, W15, P65), (A30, P70), (A30, W5, P65), (A30, W10, P60), (A30, W15, P55) Supply fuel mixture using the EFI system. Fuel flow is measured to determine the fuel consumption of the engine. Engine output is connected to the DYNOmite Land & Sea dynamometer type water brake to measure engine brake power. Measuring exhaust emissions using Stargass 898 gas analyzer. Measurement of exhaust emissions is used to determine the levels of HC and CO.

Table 1. Fuel properties

Characteristics	Wet Methanol	Gasoline	Acetone
Octane number	113.34	88.80	110
Moisture Content (% v)	24.88	0.003	-
Viscosity	0.46	0.22	0,39
Mass density (kg / m3)	793.2	774	802,6
Calorific Value (MJ / kg)	21.73	42.69	20,89
Flash Point (° C)	10.7	-7.22	18
Latent heat (KJ / Kg)	1139	328.91	519

Table 2. Engine specifications

Engine Toyota Kijang 7 K	
Engine type	Gasoline
Production	Toyota
Number of Cylinders	4
Engine capacity	1798 cc
Number of valve	(SOHC) 8 valves
Maximum power	94 hp - 5000 rpm
Maximum torque	155 Nm – 3200 rpm
Fuel system	EFI

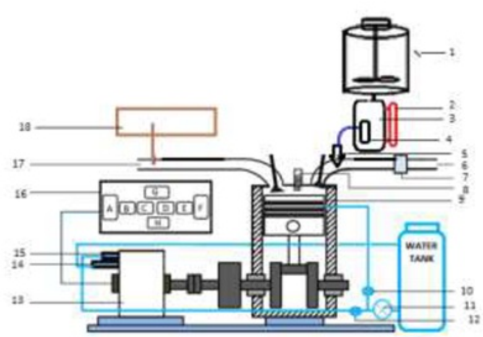

Figure1. Experimental *set up*

1. Fuel Mixer
2. Burret
3. Fuel tank
4. Fuel pump
5. Injector
6. Intake manifol
7. Throtel
8. Spark Plug
9. Cylinder block
10. Cooling water valve
11. Water pump
12. Load valve
13. Dynamometer
14. Outlet water
15. Inlet water
16. Display panel
17. Exhaust
18. Gas analyzer

Testers were carried out on 2500, 3000, 3500 and 4000 rpm engine speed variants with premium fuel mixture, acetone and wet methanol. The test engine uses the Toyota Kijang 5k engine, 4 stroke with 4 cylinder capacity of 1798 cc. Fuel flow rate is measured using a stopwatch to determine the volume of fuel being burned. Fuel mixing is done using a mixer (1). The fuel that has been mixed homogeneously is then flowed to the tank (3). In the tank there is a burette (2) and a fuel pump (4). Buret is used to determine the volume of fuel used. When the gasoline engine works, loading is carried out with a constant load. Measurement of torque and power engine using DYNOmite Land & Sea type water brake dynamometer (13). All measurement data is informed by the display panel (16). In the intake manifold and exhaust manifold the thermocouple is installed to measure the air temperature. Gas analyzer stargass 898 (18) is installed in the exhaust manifold to measure HC, CO, CO_2 and O_2 emissions.

3. Results And Discussion

3.1. Analysis of Machine Performance Testing

The test results in Figure 2, show an increase in brake power as engine speed increases.

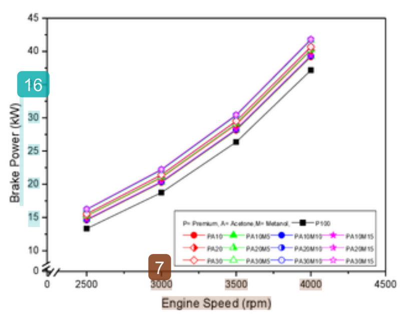

Figure 2. Brake power

The highest increase occurred in the PA30M15 mixture reaching 41.85 KW at 4000 rpm engine speed. The premium produces Brake power of 37.16 KW at 4000 rpm engine speed. The increase in brake power that occurred reached 12.62% with the use of a mixture of premium, acetone and wet methanol. Variation of acetone and wet methanol fuel mixture has an effect on engine power increase. Methanol has a low ratio of carbon and hydrogen. The high combustion speed and the high LHV cause increase the engine power output[9]. Oxygen levels and octane values affect the brake power produced by the engine. Acetone and wet methanol have high oxygen and octane values. Mixing acetone and wet methanol into the fuel causes better combustion and increases Brake power [10]. The water content in wet methanol accelerates the rate of combustion. Addition of acetone increases the peak pressure of combustion results [11].

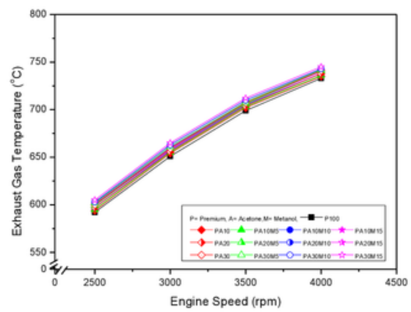

Figure 3. Exhaust gas temperature

Test results on figure 3. There is an increase in temperature in the engine exhaust gas. Increasing the temperature of the exhaust gas occurs in each mixture. The highest increase in exhaust gas temperature occurs in the PA30M15 mixture. The increase in exhaust gas temperature reaches 1.63%. PA30M15 mixture produces exhaust gas temperature of 745 °C at 4000 rpm engine speed. Premium produces exhaust gas temperature of 733 °C at 4000 rpm engine speed. Increased exhaust gas temperature is influenced by high latent heat. Latent heat of acetone and wet methanol is higher compared to premium. Acetone and wet methanol have a higher combustion rate than premium, this causes the combustion of fuel in the cylinder to be more perfect. Oxygen levels in acetone and wet methanol also affect the heat produced in the combustion process [10].

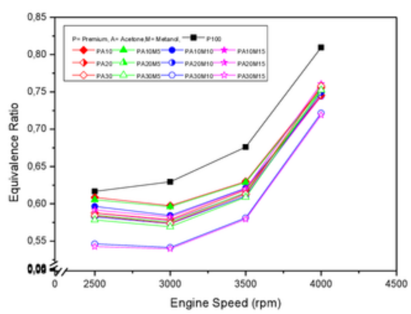

Figure 4. Equivalence ratio

The fuel entering the combustion chamber must be gas. Fuel is more flammable in gas than liquid. The easier the combustible fuel mixture produces maximum energy efficiency [12]. The combustion reaction occurs because there is fuel and oxygen. Fuel and oxygen must be mixed homogeneously. The more homogeneous the mixture of fuel and oxygen the more perfect the combustion process. Comparison of the mixture of air and fuel is strongly influenced by the type of fuel. The mixture of premium, acetone and wet methanol has increased equivalence ratio at each engine speed. The heat value and the smaller stoichiometric ratio of air-fuel causes the equivalence ratio to increase [9]. Figure 4 shows the decrease in the equivalence ratio in each mixture. Premium shows a result of 0.61 at 2500 rpm engine speed. Penuruan occurs gradually along with the large volume of premium fuel mixtures, acetone and wet methanol. The lowest decay occurred in the PA30M15 mixture at a 2500 rpm engine speed showing a result of 0.54. The decrease reached 11.47%.

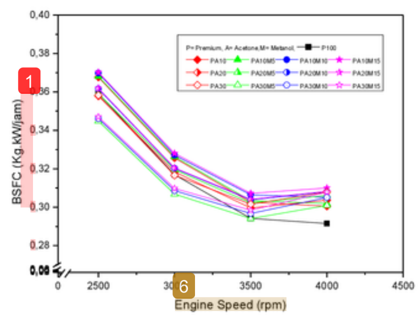

Figure 5. Brake specific fuel consumption

In Figure 5, is the result of BSFC testing. BSFC changes as the engine turns. The lowest BSFC is produced from the PA30M5 mixture at 2500 rpm engine speed. PA30M5 reaches 0.344 KG.KW/Jam at 2500 rpm engine speed. P100 is 0.35 KG.KW/ Hours at 2500 rpm engine speed. P100 experienced the lowest decrease of 0.29 KG.KW/ Hours at 4000 rpm engine speed compared to the others. The PA10M15 mixture produces the highest BSFC compared to other mixtures in each engine rotation. The average increase in PA10M15 mixed BSFC reached 4.35% compared to P100. This is due to the calorific value which is lower than gasoline.
Low heat values do not contribute to heat energy during combustion in the cylinder [11]. The low energy content of the wet methanol, acetone and gasoline mixture causes an increase in BSFC. Energy content and heat value of ethanol / methanol which is lower than gasoline causes an increase in fuel consumption compared to using gasoline [13]. A mixture of acetone butanol ethanol (ABE) on gasoline engines improves engine performance and BSFC. BSFC has increased because ABE has a lower low heating value (LHV) [14].

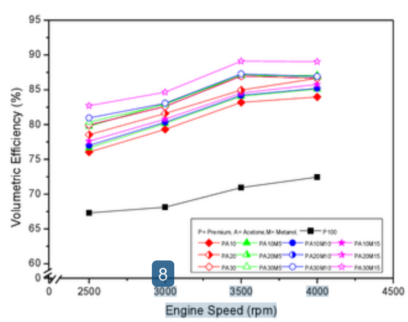

Figure 6. Volumetric efficiency

The test results show an increase in volumetric efficiency in each mixture. The biggest increase occurred in the PA30W15 mixture. These results are due to Acetone and wet methanol having higher evaporation heat than premium. The cooling effect of evaporation of acetone and wet methanol causes the temperature at the intake manifold to be low and increases volumetric efficiency [15]. stated that methanol has a higher combustion temperature than gasoline. More evaporation heat than gasoline causes the intake manifold temperature to be lower and increases volumetric efficiency. [16].

3.2. Data and Analysis of Exhaust Gas Emissions

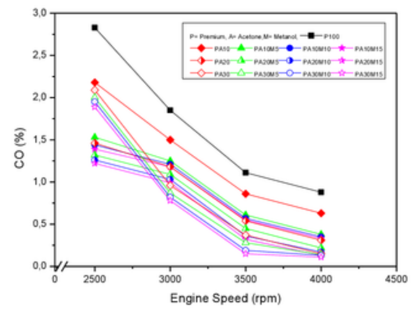

Figure 7. Emission CO

Figure 7 shows the CO level in the exhaust gas decreases in each engine rotation. Highest reduction of CO levels occur in PA30M15 mixture. PA30M15 CO levels reached 0.11% at 4000 rpm engine speed. The drop was influenced by the combustion process and the oxygen content of the wet methanol and acetone [10]. The water content in wet methanol can reduce CO reactions in the combustion process [17].

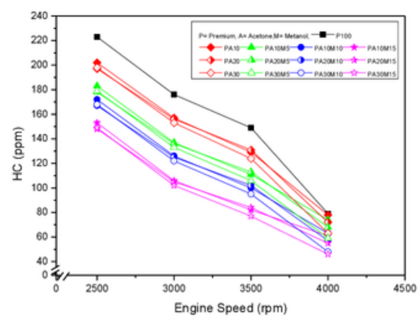

Figure 8. HC Emission

Figure 8, shows that HC emissions formed from combustion products have decreased in each mixture. In the use of P100 HC fuel which is formed reaches 79 ppm at 4000 rpm engine speed. The most significant decrease in PA30M15 mixture reached 46 ppm at 4000 rpm engine speed. The decline reached 41.77%. The decrease in HC that occurs due to more oxygen levels in the combustion reaction. Acetone and wet methanol contain oxygen compounds. When acetone and wet methanol are mixed at a premium. There is an increase in oxygen levels in the combustion chamber. Increased oxygen levels trigger more hydrogen and oxygen reactions than hydrogen with carbon [18].

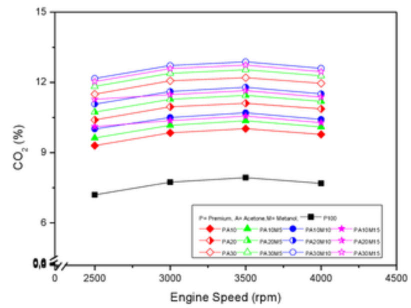

Figure 9. CO_2

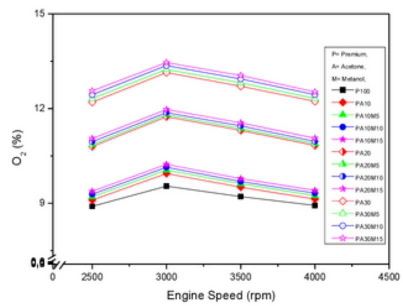

Figure 10. O_2

CO_2 emission results increase. In Figure 9, PA30M10 experienced the highest increase compared to other mixes. CO_2 levels produced by PA30M10 reached 12.88% at 3500 rpm engine speed. P100 mixture CO_2 levels reached 7.93% at 3500 rpm engine speed. At 4000 rpm engine speed, CO_2 levels decrease. PA30M10 produces 12.6% CO_2 and P100 produces 7.69% CO_2.

In Figure 10, the O_2 content in the exhaust gas emissions increases in each mixed variable. The increase occurred along with the increase in the amount of acetone and wet methanol. the least O_2 levels were produced in the P100 mixture of 9.54% at 3000 rpm. PA30M15 produced 13.46% O_2 at 3000 rpm engine speed.

Increased O_2 levels and CO_2 levels are influenced by oxygen compounds on alcohol derivatives. Addition of acetone and methanol increases combustion efficiency. Combustion efficiency increases brake thermal efficiency (BTE) and CO_2 emissions increase. CO emissions levels decrease [19]. Alcohol fuel causes rising CO_2 emissions. The ratio of oxygen in alcohol produces combustion efficiency and causes higher CO_2 emissions [20]. Acetone and methanol solutions contain several percent oxygen. When the solution undergoes a combustion process the residual results from combustion will result in an increase in O_2 and CO_2 levels [10].

4 Conclusion

The main conclusions obtained in the research on the performance and emissions of exhaust gas from EFI gasoline engines with a mixture of premium acetone and wet methanol fuels: [1] Gasoline engine performance has increased with the addition of acetone and wet methanol mixtures into premium. Acetone and wet methanol have higher octane values compared to premium. The increase in octane value in mixed fuels results in increased brake power produced. [5] The exhaust gas emission produced on the test machine has decreased. It can be seen from the decreasing levels of CO and HC contained in the combustion residual gas. O_2 and CO_2 levels have increased. Oxygen levels in wet methanol and acetone reduce the levels of HC and CO formed and increase levels of O_2 and CO_2.

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